of a complete record, but the set of fourteen drawings of the polar cap which accompany the paper show very clearly the diminution of the cap from October 15, 1902, to March 15, 1903, and its augmentation from then until July 1, the minimum apparently taking place at an earlier date than usual.

In addition to detailed descriptions of the most interesting observations, the paper contains reproductions of ten excellent drawings showing various features on the planet's surface.

NATAL GOVERNMENT OBSERVATORY.—The report of the Government Astronomer for Natal, Mr. E. Nevill, for 1902 is chiefly devoted to the various meteorological records of the colony, and forms a valuable addition to the meteorology of last year.

After giving brief descriptions of the staff, the instruments, the management of the time signals, the magnetic observations, and the tide records, the report gives a number of tables containing very complete records of the meteorological results obtained at the Durban Observatory and twenty-two inland stations, and the less complete records of twenty-six subsidiary stations which are scattered throughout the colony.

In dealing with this section of the report Mr. Nevill directs special attention to the importance of obtaining the fullest possible records of the meteorological conditions in Natal, because, in addition to their local importance, it has been shown that there is a very close connection between them and the conditions obtaining in Australia and India. In the latter case there are trustworthy indications that the meteorological conditions of Natal are those which are likely to prevail in India during the following season; this is especially marked in the case of the rainfall.

INHERITANCE OF PSYCHICAL AND PHYSICAL CHARACTERS IN MAN.[1]

THERE are probably few persons who would now deny the immense importance of ancestry in the case of any domestic animal. A majority of the community would probably admit also that the physical characters in man are inherited with practically the same intensity as the like characters in cattle and horses.

But the preeminence of man in the animal kingdom is justly attributed, not to his physical, but to his psychical character. The latter is seen developing apparently under the influences of home and of school, and we conclude, perhaps too rashly, that home and school are the chief sources of the psychical qualities. We are too apt to overlook the possibility that the home standard is itself a product of stock, and that the relative gain from education depends in a surprising degree on the raw material presented to the educator.

It is possible to hold this view and yet believe that moral and mental characters are inherited in either a qualitatively or a quantitatively different manner from the physical characters. Both may be influenced by environment, but one in a far more marked way than the other.

Some six or seven years ago, then, I set myself the following problem: What is the quantitative measure of the inheritance of the moral and mental characters in man, and how is it related to the corresponding measure of the inheritance of the physical characters?

The problem really resolved itself into three separate investigations:—

(*a*) A sufficiently wide inquiry into the actual values of inheritance of the physical characters in man.

For this investigation upwards of 1000 families were measured, giving ample means of determining the quantitative measure of resemblance for both parental and fraternal relationships.

(*b*) A comparison of the inheritance of the physical characters in man with those in other forms of life.

No substantial difference in this inheritance has been discovered.

(*c*) An inquiry into the inheritance of moral and mental characters in man.

Owing to the great difficulty of comparing the moral characters of a child with those of its adult parents, I confined my attention to *fraternal* resemblance, for if fraternal resemblance for moral and mental characters is less than, equal to, or greater than its value for physical characters, the same must be true for parental inheritance.

In the next place it seemed impossible to obtain moderately impartial estimates of the psychical characters of *adults*. The inquiry, therefore, was limited to *children*, so that the partial parent or relative could be replaced by the fairly impartial school teacher.

After much consideration and some experimenting, schedules were prepared in which teachers could briefly note the chief characteristics of the children under their charge. These schedules were white for a pair of brothers, pink for a pair of sisters, and blue for a brother and sister. With the schedules specially devised headspanners were distributed, directions for the use of the headspanner, and general directions as to the estimation of the physical and mental characters.

The material took upwards of five years to collect. Appeal was made through the columns of the educational journals to teachers of all kinds, and the observations were made not only in the great boys' public schools and the grammar schools of the country, but in modern mixed schools, in national and elementary schools of all kinds, in board schools, and private schools throughout the kingdom. Some 6000 schedules were distributed, and between 3000 and 4000 returned with more or less ample data. I have most heartily to thank the masters and mistresses of some 200 schools in which observations have been made for me. In the midst of arduous professional claims on their time and energy, they have, in many cases at considerable personal inconvenience, recorded and measured the children in their charge for a purpose only dimly foreshadowed for them.

Much of what I have to say upon the nature of the theory applied will not be new to those who have examined recent biometric work, and some of it will not be intelligible except to the trained mathematician. Still we must strive in broad lines to see how the work has been done, and, above all, to justify our treatment of the psychical character.

[To illustrate the method the lecturer examined the degree of resemblance between the cephalic indices of brothers, the cephalic index of a person being 100 × the ratio of breadth to length of head. This scarcely changes with growth after the first two years of life. A table was exhibited showing the cephalic index for 1982 pairs of brothers.]

Taking the boys, for example, with cephalic indices between 74 and 75, these boys had seventy-eight brothers who were distributed according to the column headed 74 to 75. Brothers are not alike in cephalic index, but distributed with a considerable range of variation. The arithmetic mean of the cephalic indices of this array of brothers is 77·45. Thus the average brother of a boy with cephalic index 74·5 has a cephalic index =77·45. This is the phenomenon of regression towards the general population mean (78·9) discovered by Francis Galton.

We now find by taking all the arrays that whatever the cephalic index of first brother be, cephalic index of mean second brother

$$\begin{aligned} &= (1-\alpha)\{\text{mean cephalic index of whole population}\} \\ &\quad + \alpha\,\{\text{cephalic index of first brother}\} \end{aligned}$$

and that in the case of cephalic indices for two brothers the quantity α, defined as the "resemblance," has the value 0·5.

Now from this result we have learnt two great features about inheritance in man. Firstly, that part of the cephalic index of the second brother depends in the above linear manner on that of the mean of the whole population and part on that of the first brother; and, secondly, that these parts are about equal. Are these true for other characters than the cephalic index? Undoubtedly, for all physical characters. And further, the fraction α, which we have called the resemblance, is, for brethren, in all cases about 0·5.

This surprising uniformity in the inheritance of the measurable physical characters can be extended to physical characters not capable of accurate measurement, and to psychical characters provided we assume a certain distribution of frequency for such characters in human popu-

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[1] Abstract of the Huxley Memorial Lecture for 1903. Delivered before the Anthropological Institute on October 16, by Prof. Karl Pearson, F.R.S.

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lations. Suppose, then, we assume that the moral and mental qualities in man, like the physical, follow a normal law of distribution. What results shall we obtain by thus assuming perfect continuity between the physical and psychical? I cannot free myself from the conception that underlying every psychical state there is a physical state. Hence I put to myself the problem as follows:—

Assume the fundamental laws of distribution which we know hold for the physical characters in man, and see whither they lead us when applied to the psychical characters. They must (*a*) give us totally discordant results. If so, we shall conclude that they have no application to the mental and moral attributes. Or (*b*) they must give us accordant results. If so, we may go a stage further, and ask how these results compare with those for the inheritance of the physical characters; are they more or less or equally subject to the influence of environment? Here are the questions before us. Let us examine how they are to be answered. Taking as an example *ability in girls*, we find that the resemblance between sisters is 0.47. There can, I think, be no doubt that *intelligence* or *ability* follows precisely the same laws of inheritance as cephalic index or any other physical character.

I ask you to admit that I came to this inquiry without prejudice. I expected *a priori* to find that the home environment largely affected the resemblance in moral qualities of brothers and sisters. Putting any thought of prejudice on one side, accept for a moment the methods adopted, and look at the broad results of the inquiry. You have in the first table the mean resemblance of the physical characters of brothers and sisters from my records of family measurements. You have in the second table the mean of the physical measurements of our school records. These two series absolutely confirm each other, and give a mean resemblance of 0.5 nearly between children of the same parents for all physical characters. How much of that physical resemblance is due to home environment? You might at once assert that size of head and size of body are influenced by food and exercise. It is quite true. But can any possible home influence affect cephalic index or eye colour? I fancy not; and yet these characters are within broad lines inherited exactly like the qualities directly capable of being influenced by nurture and exercise. I am compelled to conclude that the environment influence on physical characters is to the first approximation not a great disturbing factor when we consider degrees of fraternal resemblance in man.

Now turn to the list of the degrees of resemblance in the mental and moral characters. We find, perhaps, slightly more irregularity than in the case of the physical characters. The judgment required is much finer, the classification much rougher, but the obvious conclusion is still that the values of the coefficient α giving the resemblance again cluster round 0.5.

We are forced, I think literally forced, to the general conclusion that the physical and psychical characters in man are inherited within broad lines in the same manner and with the same intensity.

This *sameness* surely involves something additional. *It involves a like heritage from parents.* So we inherit our parents' tempers, our parents' conscientiousness, shyness and ability, even as we inherit their stature, forearm and span.

At what rate is that? [A table was shown which represents our present knowledge of parental inheritance in man and in the lower forms of life, the resemblance of parent and offspring being again roughly 0.5.] So the psychical characters are not features which differentiate man from the lower types of life.

If the conclusion we have reached to-night be substantially a true one, and for my part I cannot for a moment doubt that it is so, then what is its lesson for us as a community? Why, simply that geniality and probity and ability, though they may be fostered by home environment and good schools, are nevertheless bred and not created. The education is of small value unless it be applied to an intelligent race of men.

Our traders tell us we are no match for the Germans or Americans. Our politicians catch the general apprehension and rush to heroic remedies. Looking round impassionately from the calm atmosphere of anthropology, I fear there really does exist a lack of leaders of the highest intelligence, in science, in the arts, in trade, even in politics. I do seem to see a want of intelligence in the British professional man and in the British workman. But I do not think the remedy lies in adopting foreign methods of instruction or in the spread of technical education. I believe we have a paucity just now of the better intelligences to guide us, and of the moderate intelligences to be guided. The only account we can give of this on the basis of the result we have reached to-night is that we are ceasing as a nation to breed intelligence as we did fifty to a hundred years ago. The only remedy, if one be possible at all, is to alter the relative fertility of the good and bad stocks in the community. We stand, I venture to think, at the commencement of an epoch which will be marked by a great dearth of ability. We have failed to realise that the psychical characters which are in the modern struggle of nations the backbone of a State are not manufactured by home and school and college; they are bred in the bone; and for the last forty years the intellectual classes of the nation, enervated by wealth or by love of pleasure, or following an erroneous standard of life, have ceased to give us the men we want to carry on the ever-growing work of our Empire, to battle in the fore rank of the ever-intensified struggle of nations.

The remedy lies in first getting the intellectual section of our nation to realise that intelligence can be aided and be trained, but no training or education can create it. You must breed it; that is the broad result for statecraft which flows from the equality in inheritance of the psychical and the physical characters.

THE APPLICATION OF LOW TEMPERATURES TO THE STUDY OF BIOLOGICAL PROBLEMS.[1]

THE cellular doctrine lies at the basis of modern biological research. Living matter in its simple and complex conditions consists essentially of protoplasm with a contained body or nucleus. The two elements plasma and nucleus constitute the elementary organism—the cell. The lowest individual forms of life are represented by a single cell, and such unicellular organisms may be either of a vegetable or animal type. The cells in each instance exist as free living and independent organisms. The higher forms of life are built up of parts in which the structural unit remains the cell, despite the modifications the cell necessarily undergoes as a fixed element in the various tissues and organs. All phases of animal and plant life are demonstrably of cellular origin and organisation, and their vital manifestations represent the summed up activities of cells. Every vital problem, therefore, is ultimately a cellular problem, and a direct study of the cell, in so far as may be possible, is the keynote of biological research. The methods to be adopted will depend upon the problem it is desired to investigate. A histological technique, aided by the microscope, will naturally be employed where it is desired to study the relations of parts and the structural organisation of the tissues and their cellular elements. The soluble products of the living cell spontaneously present themselves for examination by chemical and other means. It is otherwise with regard to the agencies acting and the processes occurring within the confines of the cell. These are naturally beyond the range of the ordinary methods of observation. The essential processes of life are intracellular and intimately bound up with the living substance of the cell, and of these but few data are possessed. The importance of the problems involved is as great as their investigation is difficult. The cell exercises its vital functions in virtue of a specific physical and chemical organisation of its molecular constituents. The ordinary methods of biological and chemical research modify or destroy this organisation, and do not admit of an intimate study of the normal cell constituents. For this purpose it is essential to eliminate or to reduce to a minimum the influence of external modifying agents on the cell or its immediate products. An intracellular physiology can only be based on a direct study of intracellular constituents apart from their secretions and products. This, in ordinary circumstances, is impossible with

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[1] By Dr. Allan Macfadyen. Communicated to Section B of the British Association at Southport, by Prof. J. Dewar, F.R.S.

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